SUSTAINANABLE AGRICULTURE FARMING SYSTEMS PROJECT

University of California, Davis

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SAFS past, present, future

By Leisa Huyck, SAFS research manager

The Sustainable Agriculture Farming Systems (SAFS) project at the University of California, Davis is embarking on a new phase. SAFS is an effort established in 1988 by a multidisciplinary team of researchers, farmers, and farm advisors to study the transition from conventional to low-input and organic systems. The first phase of the SAFS project was concluded with the growing season of 2000.

The new phase is examining the possibilities for conservation tillage in various cropping systems, with the goal of understanding the biological changes, systems-levels flows of nutrients and water, and economics that occur when tillage is greatly reduced.

Our newsletter is being produced as part of a grant from CALFED, a consortium of federal and state agencies charged with, among other things, restoring the ecosystems of watersheds feeding into California's Bay-Delta watershed. We are appreciative of CALFED's support, as well as the support of the California Department of Food and Agriculture (CDFA) and Unilever Bestfoods Corporation, a major buyer of California processing tomatoes. The three organizations are interested in the questions raised by our first 12 years of research that indicate alternative farming practices could make a significant contribution to solving problems and concerns of California growers, consumers and policymakers. All three are funding our new set of studies that would broaden the geographical and conceptual scope of our research.

Since agriculture is one of the most extensive land uses in California, it is the biggest consumer of water from watersheds feeding into the Bay-Delta and is believed to have had the most impact on water quality. Agriculture is an essential land use that provides food, fiber, open space, wildlife habitat, and floodwater retention. Yet it has also increased runoff, increased erosion, increased sediment and nutrient loading to streams, destroyed wildlife habitat and decreased biodiversity, disrupted carbon and other element cycles, and increased air pollution—all of which damage the very ecosystems upon which agriculture depends. It is vital that research be conducted on alternative farming practices and systems that can contribute to the rehabilitation of these ecosystems.

photo by Brian Joyce

Water runs off conventional fields (left), but percolates into soils managed with cover crops (right).

At the same time that the SAFS project was able to secure grants for this research, UC Davis' College of Agricultural and Environmental Sciences provided a permanent site for our research at the Long-Term Research in Agricultural Systems (LTRAS) experiment fields at the Russell Ranch west of the UCD campus. The similar management history at this site allowed SAFS experiments to continue uninterrupted. The College also supported our move as part of its new Sustainable Agriculture initiative.

Results from the first phase of SAFS

The SAFS project compared four farming systems: organic, low-input, and conventional four-year rotations, and a conventional two-year rotation. Cash crops in the four-year rotations included processing tomatoes, safflower, dry beans, wheat, and corn. The two-year- rotation was tomatoes and wheat. Among the most important findings of the SAFS project were the following:

- Yields of all crops in all systems were close to or slightly above Yolo County averages, with differences among systems less than differences between years.
- The organic system with premium prices was the most profitable of all the systems; however, without premium prices the organic system lost money.
- Soil organic carbon in the organic system increased by 5 t/ha in 10 years. These results were obtained despite additional tillage operations in the organic plots for cover crop incorporation.
- Water infiltration rates were over 50 percent higher in the organic and low-input systems. In the winter of 1999-2000, less than 15 percent of rainfall in these systems was lost as runoff, compared to 43 percent in the conventional systems. Soil water storage was significantly greater in the organic and low-input systems.
- The conventional farming systems were least efficient at storing excess N while the low-input farming

system was the most efficient. Thus, N losses were greatest from the conventional, intermediate from the organic, and least from the low-input farming system. However, nitrogen availability was an occasional problem in the organic corn and tomato systems.
- Arthropods, pathogens, and nematodes had little influence on crop yields. Weeds resulted in small but detectable yield loss, with higher weeding costs in some years, particularly in the organic system.
- Energy efficiency was greatest in the low-input system.

These results have led us to speculate about what other practices might contribute to developing a more sustainable agriculture in California, as well as what would happen if they were adopted on a large scale. If cover cropping could bring about the changes in soils that we saw on the SAFS plots, what more could reducing soil tillage do?

Conservation tillage

Conservation tillage (CT) is a category of agricultural practices that have reduced production costs, reduced nonpoint source pollution, improved air quality, and increased carbon sequestration in many other parts of the country and world. Yet five years ago, CT was virtually unheard of in California, and no scientific information existed on whether or not CT could work in California conditions. Could CT further improve the sustainability of California agriculture and the quality of the California environment?

New location, new purpose

The SAFS project now has both a new location and a new purpose. The purpose of the new project is threefold:

1) to study the effects of conservation tillage and cover cropping on the export of sediment, nutrients, and pesticides in runoff from conventional and organic farming systems;
2) to evaluate the feasibility and sustainability of conservation tillage and cover cropping, and quantify their ecological benefits and economic costs and the tradeoffs between them; and
3) to extend the results of the study and demonstrate conservation tillage and cover cropping to interested parties.

The geographic scope of the project expanded as the purpose expanded. We are making measurements at several sites provided by growers in Yolo and Stanislaus counties, in order to characterize the relationships between management practices and runoff in different geographic locations.

Growers and farm advisors remain a vital part of our research team, participating in every phase of the research, from planning and execution to interpretation and dissemination of results.

Main site study design

Beginning with the 2003 growing season, at the main Russell Ranch site plots of one-half acre each are being farmed with CT and standard tillage (ST) in conventional, organic, and cover-cropped systems (Figure 1). The rotation is a four-year, three crop rotation, meaning that for the first two years, all three farming systems will initially consist of a two-year rotation of tomatoes and corn, with half the plots starting at each entry point in the rotation. After the first two-year tomato-corn rotation cycle, crop rotations will be "reset," by choosing a crop opposite tomatoes using an optimization strategy based on current market and other conditions. There are three replications of each system/treatment/crop combination.

Data are being collected on soil biological, chemical, and physical properties; plant growth and crop yields; water infiltration and runoff water quality and quantity; pest and disease incidence; dust emissions; production costs; and numerous other characteristics of these systems. These data will be used to conduct the ecological-economic cost-benefit analysis, as well as to evaluate both the viability and the sustainability of the farming practices and systems under study.

At growers' fields, comparisons are being set up in conventional systems either between CT and ST, or cover cropping and no cover cropping. The main goal of these comparisons is to measure runoff quantity and quality from the fields being studied.

Companion studies

In addition to the main plots at the Russell Ranch, there is a 14-acre area being used for several companion studies. The general purpose of these studies is to refine management practices and strategies for successful use of CT and cover cropping in Yolo County conditions. Subjects of these studies include:

- An evaluation of the effects of drip vs. furrow irrigation on weed control and carbon fluxes in conventional CT and ST processing tomato systems (funded by Unilever-Bestfoods Corporation).
- An assessment of alternative cover crop mixes for use in CT systems, and their carbon and nitrogen budgets (funded by CALFED and the Jastro-Shields Foundation).
- The evaluation of warm and cool season cash crops such as garbanzo beans for their compatibility with CT production systems.
- Monitoring changes in soil food webs, carbon flow, and soil carbon storage in legume-vegetable rotations managed with conservation or standard tillage practices (funded by Kearney Foundation of Soil Science in conjunction with the CDFA Specialty Crops Program).

We are pleased to report our progress to you, which will continue in quarterly updates.

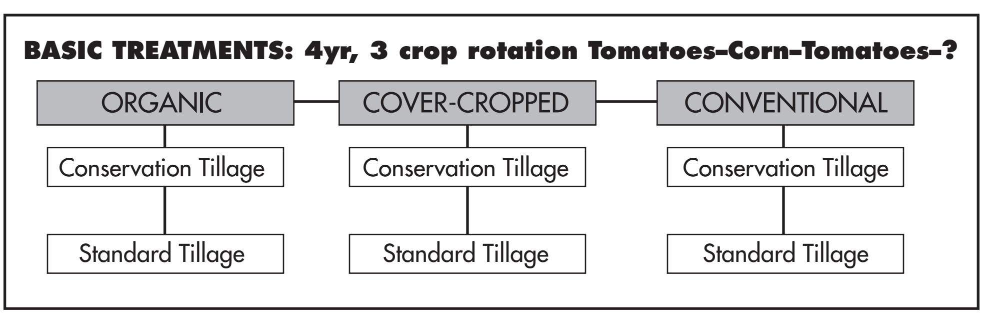

Figure 1. SAFS Study Design

SAFS 2003 field experience

by Dennis Bryant, LTRAS associate director and Leisa Huyck, SAFS research manager

Tomato Production Systems

The new study began in April 2003. In the cover-cropped and organic standard treatments (ST)treatments, cover crops (CCs) were flail-mowed slightly above the bed surface. The organic systems received a bed top application of composted poultry litter. A relatively lightweight bed-preserving disc (Hahn) was used to mix the CC residue and the compost in the beds. The beds were then lightly shanked with a cultivating sled and mulched with an all-purpose power incorporator.

In the conservation tillage (CT) organic systems, compost was applied on the bed top to the standing CC, which was then flail-mowed and allowed to lie as it fell. Strip tillage was then emulated using a three-point Clampco fertilizer applicator with a coulter disc wheel and two shanks per bed, on a single pass, to dry out and aerate the extremely wet soil.

In the conventional ST treatment, a Perfecta II was used to aerate the soil surface and for control of minor weed growth. A cultivating sled with various shanks was then followed by a bed center herbicide incorporation/mulching. During the season there were two light mechanical cultivations and an additional lay-by incorporation. Preplant (15-15-15) and in-season granular fertilizer (ammonium sulfate) was shanked into the beds with a Clampco affixed with a coulter disc. In the CT system, only the preplant bed center strip till operation was used.

Tomato seedlings were transplanted in all systems using typical Holland transplanters affixed with a single coulter disc opener per bed. The wetness of the soil, coupled with the weight of the equipment, led to heavy compaction. The center furrows were compressed to depths of 14 inches. The extreme depth and non-uniformity of CT furrows created at transplanting led to further difficulties with planned cultivations and irrigations, as well as mechanical difficulties with harvesting.

Corn Production Systems

Field operations in the CC and organic corn systems were similar to those described for tomatoes with respect to CT and ST treatments. Whether the CC and compost had been thoroughly mixed into the soil (ST) or left to remain on the surface (CT), all corn plantings succeeded in establishing excellent stands. In the CT treatment this was achieved using coulters mounted in front of the seed openers, and a combination of smooth and spiked seed cover wheels. The coulters were successful in cutting the vetch/pea residue without sweeping it to the side. It was also possible to plant to depth into adequate soil moisture.

Weed control was achieved in the CT treatment with pre-plant and in-season Roundup applications. In the ST comparison, the beds were lightly harrowed with a Perfecta II to aerate and incorporate a pre-plant herbicide application. An additional furrow sweep cultivation was used to retain bed/furrow integrity after shank fertilizer application.

Two major problems emerged in the CT organic and CC corn relative to the ST corn in the same systems. One was an apparent nitrogen deficiency in the crop. A pale yellow leaf color and reduced plant height were observed by one month after emergence. These remained until tassel emergence, when early senescence masked these characteristics. The other main problem was the inability of available equipment to adequately cultivate weeds in the organic CT treatment.

Preliminary yield data appear to reflect differences in management practices, though they have not yet been analyzed for statistical significance (Table 1). How much the differences will change as production managers become more familiar with new practices remains to be seen.

Table 1. Preliminary yields of processing tomatoes and field corn, 2003.

Corn (lbs/acre at 15.5 % moisture

	Organic	CC	Conv
CT	6876	6415	13051
ST	7819	7452	12602

Tomatoes (tons/acre fresh weight)

	Organic	CC	Conv
CT	25.1	15	20.6
ST	26.8	17.1	20.0

Conservation Tillage

What do we mean by "Conservation Tillage" (CT)?

Production systems that reduce or minimize primary tillage operations between crops, such as ripping, chiseling, disking or plowing. In these systems, more crop residues may persist on the soil surface and will have to be dealt with as the cropping cycle continues.

CT production systems have several attributes that California producers may find attractive. These include opportunities to:

- reduce production costs,
- reduce fuel use, and labor,
- reduce dust and NO_x emissions,
- reduce surface water runoff and sediment, nutrient and pesticide losses, and
- store more carbon in the soil.

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